National Aeronautics and Space Administration

NASAfacts

Dynamic Weather Routes (DWR)

What's the Problem? Severe thunderstorm activity is the leading cause of delay in the US National Airspace System. When such weather is present or forecast on preferred flight routes, weather avoidance routes are selected usually 1-2 hours before takeoff, and often include large buffers to compensate for forecast uncertainty. As flights progress, airline dispatchers and Federal Aviation Administration (FAA) traffic managers strive to find improved routes to reduce delay. However, operators are busy, especially during weather events, and may miss opportunities for more time- and fuel-efficient routes. Automation does not exist to help operators determine when weather avoidance routes could be modified or eliminated to reduce delay.

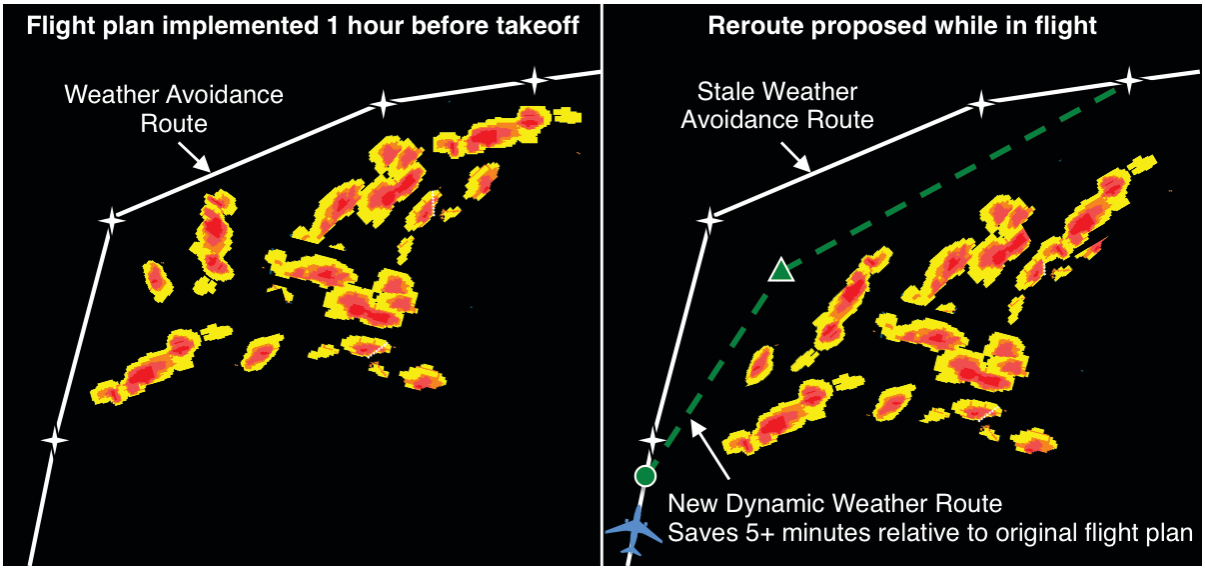
What's NASA Doing to Help? NASA is developing a ground-based automation system and tool called ***Dynamic Weather Routes (DWR)***. DWR is a search engine that continuously and automatically analyzes in-flight aircraft in en route airspace to find time- and fuel-saving corrections to weather avoidance routes. Route corrections are simple reroutes like those typically used in today's operations.

Every 12 seconds, DWR computes and analyzes trajectories for en route flights. DWR first identifies flights that could save 5 or more flying minutes (wind-corrected) by flying direct to a downstream "return" fix on their current flight plan. Eligible return fixes are limited so as not to take flights too far off their current route or interfere with arrival routings near the destination airport. Usually such direct routes, ones that can save 5 or more minutes, even with limits, are due to route segments included to avoid weather. Using the direct route as a "reference route," DWR inserts up to two auxiliary waypoints as needed to find a minimum-delay reroute that avoids the weather and returns the flight to its planned route at the downstream fix. If a reroute is found that can save 5 minutes or more relative to the current flight plan, the flight is posted to a list displayed to the airline or FAA user. Auxiliary waypoints are defined using fix-radial-distance format, but a "snap-to" option utilizes nearby named fixes for ease of use in today's operations. Users may also adjust the alert criteria, nominally set to 5 minutes, based on their workload and desired potential savings for their flights.

In addition to the primary en route Center traffic data input to DWR, national traffic data are used to test DWR-advised routes for downstream sector congestion on both the flight plan and the DWR routes. DWRs are also tested for conflicts with active special use airspace and for FAA route restrictions (Traffic Management Initiatives).

A graphical user interface enables users to visualize proposed routes on a traffic display and modify them if necessary using point, click, and drag inputs. If needed, users can adjust the reroute parameters including the downstream return fix, any inserted auxiliary waypoints, and the maneuver start point. Reroute metrics, including flying time savings (or delay) relative to the current flight plan, proximity to current and forecast weather, downstream sector congestion, traffic conflicts, and conflicts with special use airspace are all updated dynamically as the user modifies a proposed route.

Potential Benefits. An analysis of all Fort Worth Center (ZFW) traffic, excluding Dallas (DFW and DAL) arrivals, from 18 Nov 2012 to 30 Jun 2013 indicates a potential savings of 115,018 flying minutes for 11,746 flights, or 9.8 minutes per flight on average. On heavy weather days the potential savings for some DWR routes is 20, 30, 40, or more minutes for an individual flight.



DWR user display at American Airlines Integrated Operations Center, Fort Worth, Texas.

Graphical user interface showing a trial Dynamic Weather Route (DWR)

In today's operations, some flights get favorable reroutes without DWR when pilots request short cuts or when controllers issue route amendments. To account for this, actual ZFW route amendments were analyzed. Results from the November to June sample cited above, show that flights for which DWRs were advised received route amendments resulting in 36,285 minutes savings, or about 30% of DWR potential savings, but without DWR automation. One objective is to determine what portion of the 70% of savings left unrealized is achievable using DWR automation.

Evaluation at American Airlines. Since July 2012, DWR has been in operation at the American Airlines (AA) Integrated Operations Center in Fort Worth, Texas, where NASA and AA are conducting an operational evaluation of DWR. Only AA flights in ZFW airspace are included in the evaluation. A DWR display runs at the Air Traffic Control (ATC) Coordinator Desk where an audible alert sounds when a new AA flight is first posted to the DWR Flight List. An AA ATC coordinator evaluates the proposed route and consults with the dispatcher responsible for the flight. If both agree on the reroute, the ATC coordinator clicks an "Accept" button on the DWR user display, and the dispatcher sends the reroute to the flight crew (via ACARS). The flight crew evaluates the reroute and, if they concur, requests a route change from air traffic control, using today's normal procedures.

Results. Evaluation results for the period 31 Jul 2012 to 5 Nov 2013 show that 59% of routes advised by DWR and evaluated by AA users were rated acceptable. Potential savings for DWRs rated acceptable totaled 4,403 flying minutes for 808 flights. The primary conditions cited by AA users for not accepting an advised DWR were: proximity to merging arrival streams, routes through weather gaps, FAA routing restrictions (playbook or coded departure routes), and sector congestion. Staffing limits at AA prevented all advised DWRs from being evaluated by AA (25% were evaluated), so acceptable savings is potentially higher.

An analysis of actual ZFW route amendments that followed DWRs rated acceptable by AA indicates an estimated actual savings attributed to DWR of 1,241 minutes for 260 AA revenue flights.

This estimate is conservative because DWR route amendments that occur after flights pass into a neighboring Center are not included in the analysis. It is not known why specific AA-accepted DWRs did not result in actual route amendments issued by ATC. However, six traffic management experts familiar with ZFW airspace operations evaluated a sampling of AA-accepted DWRs. Proximity to arrival streams and workload associated with inter-Center coordination were cited as the primary reasons to reject a route request. Researchers are continuing to investigate obstacles to issuing route amendments, and conditions under which routing restrictions may be relaxed, so that more DWRs are acceptable as advised.

A tool-used vs. not-used analysis was conducted using 34 heavy weather days, all with high potential savings for AA. Results indicate that AA flights realized about 10% more of advised DWR savings over 16 days where DWR was heavily used vs. 18 days where DWR was lightly used. This equates to 586 minutes savings directly attributed to DWR on the 16 heavy-use days, or about an $88,000 savings in operating costs assuming an overall average operating cost of $150/minute.

A sector congestion analysis based on AA accepted DWRs for 83 flights during the first three months of the evaluation indicates that congestion on DWR routes, as measured by the Monitor Alert Parameter, is about the same or better as that on the as-flown tracks. A fuel burn and emissions analysis for the same flights indicates an 8% fuel savings and a 6-8% reduction in emissions for accepted DWR routes compared to the as-flown tracks.

Next Steps. AA feedback has been favorable, and other airlines, aerospace companies, and the US Air Force have expressed interest in the DWR concept and software. NASA is supporting technology transfer of DWR for commercialization, and DWR automation is being leveraged to find common reroutes for groups of flights, including arrival streams merging and descending into the terminal area.

For more information on Dynamic Weather Routes (DWR) please visit:

www.aviationsystems.arc.nasa.gov.

National Aeronautics and Space Administration

Ames Research Center
Moffett Field, CA 94035
www.aviationsystems.arc.nasa.gov

www.nasa.gov